Modular Backplane for Industrial Computers

Field of the Invention

The present invention relates generally to a backplane of an industrial computer system, and particularly relates to a modular backplane comprising a plurality of backplane segments which are bridged together by a low-profile bridge module.

Background of the Invention

Conventionally, a computer system utilizes a bus as a pathway or channel for data communication among the components of the system. A popular bus architecture is the PCI (Peripheral Component Interconnect) bus architecture. The PCI bus standard (specification) is well suited to personal computers. There are, however, numerous limitations of the PCI bus specification that make the bus impractical for industrial computers.

In order to provide a standard form factor for industrial computers, the PCI Industrial Computer Manufacturers Group (PICMG™) has prepared the Compact PCI Specification that employs mechanically robust connectors and has a bus that conforms to the PCI Specification. This Compact PCI bus architecture is an implementation of PCI technology designed for industrial and/or embedded applications. The Compact PCI standard also has limitations on certain design aspects, such as the number of slots on the bus. More specifically, the Compact PCI standard defines that the PCI compliant bus has a maximum of eight electrical loads. This means that the backplane of a computer system is limited to have a maximum of eight slots.

Accordingly, it would be desirable to be able to provide a backplane of an industrial computer with more than eight slots (electrical loads). Several attempts have been

made for provision of more than eight slots on the backplanes of industrial computer systems.

One of the most recent attempts is illustrated in FIGs. **1A** to **2B**, which is described in U.S. application Serial No. 09538733 of Steven J. Mercer, et al., filed on March 30, 2000. As shown in the figures, this approach relates to a modular backplane having two or more backplane segments, which are bridged by a bridge module and, respectively, include a PCI compliant bus, although the figures illustrate only two backplane segments for convenience of description. The modular backplane **10** comprises two backplane segments **20** and **40** bridged by a bridge module **60**, where the segment **40** acts as a primary or beginning segment and the segment **20** as a secondary or ending segment, which means that a system board is supposed to be inserted into the beginning segment **40**. FIGs. **1A** and **1B** show a configuration of the front side and back side of the segments. Each segment has a front side **22** (**44**) and a back side **24** (**44**) and the front sides **22**, **42** includes several slots (**S1** to **S7**), which are for the insertion of a system board and peripheral boards. Each of the slots consists of five connectors (**J1** to **J5**). FIG. **2A** shows the back sides **24**, **44** of the backplane segments **20**, **40** bridged by the bridge module **60**, and FIG. **2B** is a frontal elevation view of FIG. **2A**. As is shown in FIGs. **1B** and **2A**, the back sides **24**, **44** of the segments **20**, **40** also includes several slots (**S1** to **S7** respectively) of two different lengths, in which the long slot **46**, **48** in the primary segment **20** and **26**, **28** in the secondary segment **40** serve as bridge modular slots for the insertion of the bridge module **60**. More specifically, the connectors **J1** and **J2** of the slots **26**, **46** denote a bridge module primary slot, and the connectors **J1** and **J2** of the slot **28**, **48** denote a bridge module secondary slot. The remaining short slots may be utilized for other add-in cards such as a transition module.

As depicted in FIGs. **2A** and **2B**, the bridge module **60** comprises a circuit board **62**, a bridging IC **64**, and a pair of connectors **66a**, **66b**. The connector **66a** is engaged with the bridge module primary slot **46** of the primary (or beginning) backplane segment **40**, while the connector **66b** is engaged with the bridge module secondary slot **28** of the secondary (or ending) segment **20**, as is clearly depicted in FIG. **2B**. Therefore, a busing between the primary and secondary backplane segments **40**, **20** has been established. In the case shown in the figures, a system board may be inserted into the slot **S7** of the front side **42** of the primary backplane segment **40**, which is exactly opposite to the bridge module secondary slot **48**. By using another bridge module, another backplane segment may be connected to the right side of the secondary (ending) segment **20** in FIG. **2A**, such that two or more backplane segments can be communicatively interconnected to each other by bridge modules, thereby providing more than eight slots (electrical loads) on the backplanes of industrial computers.

However, this approach embraces several disadvantages that must be solved. Firstly, it is inevitable that the back side bridge slot share its pins, in part, with the front side peripheral board slot, backwardly opposite to the bridge module slot. Therefore, the type of the board to be inserted into the front side peripheral board slot is limited. Also, the signaling of the bridge module is limited by that of the peripheral board inserted into the front side slot, and vice versa. Secondly, as is shown in FIG. **2B**, it is also unavoidable that the bridge module, when engaged, protrude excessively over the height of the back side bridge slot. This implementation does not meet the governing standard (IEEE 1101.11), which allows for components of the backplane to protrude no more than 19.94 mm, measured from the front surface of the backplane. The bridge module of this technology protrudes around 24 mm from the front surface of the backplane.

Furthermore, the protrusion of the bridge interferes potentially with the insertion of add-in cards, such as transition modules, into the back side slots.

Summary of the Invention

In accordance with the present invention, there is provided an improved modular backplane having a low-profile bridge module for industrial computers, in which the modular backplane comprises a first modular backplane segment, a second modular backplane segment, and a bridge module bridging the first and second backplane segments. The first backplane segment includes a first front side and a first back side, in which the first front side has a plurality of slots and the first back side has a first dedicated connector. The second backplane segment includes a second front side and a second back side, in which the second front side has a plurality of slots and the second back side has a second dedicated connector. The bridge module includes a circuit board, a bridging integrated circuit, and a pair of connectors. One of the bridge connectors is engaged with the first dedicated connector and the other is engaged with the second dedicated connector, such that the two backplane segments can be connected to each other communicatively.

The slots provided in the first front side may provide for the insertion of a system slot board and a plurality of peripheral boards and all of the slots in the second front side may provide for the insertion of a plurality of peripheral boards, and vice versa. The first back side and the second back side each may further include a plurality of slots, which may provide for the insertion of add-in cards such as a transition module.

Preferably, the modular bridge is of a low-profile, such that the height of the bridge module is less than 16 mm, the width less than 12 HP, and the length less than 94

mm. The first and second dedicated connectors are formed in an area where no slot is formed.

In accordance with a further aspect of the present invention, there is provided another improved modular backplane having a low-profile bridge module for industrial computers, in which the modular backplane generally comprises a plurality of modular backplane segments and a plurality of bridge modules for bridging the modular backplane segments. Each modular backplane segment includes a front side and a back side, in which the front side has a plurality of slots and the back side has a primary dedicated connector and a secondary dedicated connector. Each bridge module includes a circuit board, a bridging integrated circuit, and a pair of connectors. One of the bridge connectors is engaged with the primary dedicated connector in one of the backplane segments and the other connector is engaged with the secondary dedicated connector in its neighboring segments, and vice versa, such that all the modular backplane segments are communicatively connected with another.

The slots provided in the front side of one of the backplane segments may provide for the insertion of a system slot board and a plurality of peripheral boards and all of the slots in the front side of the remaining backplane segments for the insertion of a plurality of peripheral boards. The first back side may further include a plurality of slots, which may provide for the insertion of add-in cards such as a transition module.

Preferably, the modular bridge is of a low-profile, such that the height of the bridge module is less than 16 mm, the width less than 12 HP, and the length less than 94 mm. The dedicated connectors are provided in an area where no slot is formed.

Therefore, in contrast to the previous approach, the present invention provides greater flexibility in the type and the number of peripheral boards to be inserted into the front side of the backplane, and in the type and the number of the signals to be accommodated on the peripheral board and the bridge module. Furthermore, it eliminates any interference by the bridge module with the insertion of add-in cards, such as transition modules, into the back side slots of the backplane.

Accordingly, it is an object of the present invention to provide an improved modular backplane configuration having a dedicated connector for a bridge module, in which a greater flexibility in the type of and the number of slots and the peripheral boards inserted thereto can be allowed in the front side of the backplane segments.

It is another object of the present invention to provide an improved modular backplane configuration having a dedicated connector for a bridge module, in which a greater flexibility in the type and the number of signals can be allowed not only in the bridge module of the back side but in the peripheral board of the front side of the backplane segments.

It is another object of the present invention to provide an improved modular backplane configuration having a dedicated connector for a bridge module, in which the insertion of add-in cards in the back side can not be interfered by the implementation of the bridge module.

It is another object of the present invention to provide an improved low-profile bridge module which can accomplish the above-described objects of the invention.

A further understanding of the other features, aspects, and advantages of the present invention will be realized by reference to the following description, appended claims, and accompanying drawings.

Brief Description of the Drawings

The embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1A is a schematic view of the front side of an earlier type of modular backplane;

Figure 1B is a schematic view of the back side of the earlier type of modular backplane;

Figure 2A is a schematic plan view of the earlier type of modular backplane with a bridge module engaged;

Figure 2B is a frontal elevation view of the Figure 2A;

Figure 3 is a schematic plan view of the back side of a modular backplane in accordance with the present invention;

Figure 4A is a schematic view showing the outer surface configuration of a bridge module in accordance with the present invention;

Figure 4B is a schematic view showing the inner surface configuration of the bridge module in the Figure 4A;

Figure 5A is an enlarged view of the portion indicated by A in the Figure 3;

Figure 5B is a frontal elevation view of the portion indicated by A in the Figure 3;

Figure 6 is a schematic plane view of the back side of another modular backplane in accordance with the present invention;

Figure 7A is a schematic view showing the outer surface configuration of another bridge module in accordance with the present invention;

Figure 7B is a schematic view showing the inner surface configuration of the bridge module in the Figure 7A;

Figure 8A is an enlarged view of the portion indicated by B in the Figure 5;

Figure 8B is a frontal elevation view of the portion indicated by B in the Figure 5; and

Figure 9 is a schematic plan view of the back side of a monolithic backplane in accordance with the present invention.

Detailed Disclosure of the Preferred Embodiment(s)

In general and briefly, a modular backplane of the present invention has differences from the earlier type as described above, in that the backplane has a dedicated connector for a bridge module, and that the bridge module is of a low profile. Therefore, greater flexibility can be allowed in the type and the number of peripheral boards to be inserted into the front side of the backplane, and in the type and the number of the signals to be accommodated on the peripheral board and the bridge module. Furthermore, no

disturbance occurs with the insertion of add-in cards, such as transition modules, into the back side slots of the backplane.

FIGs. **3** to **5B** illustrate a preferred embodiment of the present invention which represent a modular backplane with a low-profile bridge and is denoted generally by a reference numeral **100**. This embodiment is a specific 32-bit implementation of the invention, which is designed for 32-bit industrial computers. As shown in FIG. **3**, the modular backplane **100**, in general, comprises a beginning (or primary) modular backplane segment **140**, an ending (or secondary) modular backplane segment **120**, and a bridge module **160** bridging the beginning and ending backplane segments **140**, **120**. All the backplane segments include a PCI compliant bus. In the embodiment, a system board may be supposed to be inserted into one of the slots in the front side (not shown) of the beginning backplane segment **140**.

FIG. **3** shows a configuration for the back sides **144**, **124** of the beginning and ending segments **140**, **120**, of which front side configuration may be identical to that illustrated in FIG. **1A**. In this embodiment, the back side **144** of the beginning backplane segment **140** comprises a plurality of short slots (**S1** to **S7**), each of which consists of several connectors (**J3** to **J5**), and a dedicated connector **146** for acceptance of the bridge module **160**. Similarly, the back side **124** of the beginning backplane segment **120** comprises a plurality of short slots (**S1** to **S7**), each of which consists of several connectors (**J3** to **J5**), and a dedicated connector **126** for acceptance of the bridge module **160**. The type and the number of the slots (**S1** to **S7**) are not considered to limit the present invention.

The bridge module **160** includes a circuit board **162**, a bridging IC **164**, and a pair of connectors **166a**, **166b**, as is clearly shown in the figures. FIGs. **4A** and **4B** are plan views of the outer side and inner side respectively of the bridge module **160**. FIG. **5A** is an enlarged view of the portion indicated by **A** in the figure **3**, and FIG. **5B** is a frontal elevation view of FIG. **5A**, both of which show clearly the configuration for the engagement of the bridge module **160** with the two modular backplane segments **120**, **140**. The bridging IC **164** is attached to the outer surface, however, it may be engaged with the inner surface of the circuit board **162**, depending on the design of the circuit board routing.

As is apparent from FIGs. **5A** and **5B**, the bridge connector **166a** of the bridge module **160** is engaged with the dedicated connector **146** of the beginning segment **144**, and the bridge connector **166b** is engaged with the dedicated connector **126** of the ending segment **120**, such that a bushing communication between the beginning and ending segments **120**, **140** can be established, and therefore the two backplane segments can be interconnected communicatively to each other.

Referring to FIG. **5A** and **5B** again, the dedicated connectors **126**, **146** of the backplane segments **120**, **140** are formed in the area exclusive of where a slot is formed not only in the back sides, but also the front sides of the backplane segments. Therefore, in contrast to the earlier approach, the present invention does not limit the type of the peripheral board to be inserted into the front side of the backplane segments. Also, it provides a greater flexibility in the signaling mode of the peripheral board and the bridge module as well. In this embodiment, the dedicated connectors **126**, **146** are formed in the area such that the width W of the bridge module (shown in FIG. **4A**) can be minimized, specifically, as shown in FIG. **3**, between the respective pair of slots of two neighboring

pairs of slots in the front sides of the beginning and ending backplane segments. Preferably, the width of the bridge module **160** may be less than 12HP.

Providing the dedicated connectors for a bridge module makes the bridge module itself to be able to be compact in its dimensions, such as the height **H**, the width **W**, and the length **L** which are depicted in FIG. **4A** and **5B**. Preferably, in this specific embodiment, the height **H** of the bridge module **160** may be made less than 16 mm, which meets the governing standard IEEE 1101.11 and it does not protrude over the slot, thereby not interfering with the insertion of add-in cards into the back side slots of the backplane segment. The width **W** of the bridge module may be reduced to less than 12 HP, and the length **L** to less than 50 mm, which can also enhance the flexibility in acceptance of add-in cards in the back side of the modular backplane.

Preferably, the back sides **124**, **144** of the backplane segments **120**, **140** may further include additional dedicated connectors **128**, **148** respectively, so that, by using an additional bridge module, a further backplane segment can be bridged to the right-hand side or the left-hand side of the backplane **100** shown in FIG. **3**. In this way, two or more backplane segments may be bridged, thereby extending the number of the front side slots for peripheral boards, while providing a great flexibility in selecting the type of peripheral boards and the bridging signal mode.

FIGs. **6** to **8B** illustrate another preferred embodiment of the present invention which represent a modular backplane with a low-profile bridge and is denoted generally by reference numeral **200**. This embodiment is a specific 64-bit implementation of the invention, which is designed for 64-bit industrial computers. Similarly to the previous embodiment, the modular backplane **200**, in general, comprises a beginning (or primary)

modular backplane segment **240**, an ending (or secondary) modular backplane segment **220**, and a bridge module **260** bridging the beginning and ending backplane segments **220**, **240**. All the backplane segments include a PCI compliant bus. In the embodiment, a system board may be supposed to be inserted into one of the slots in the front side (not shown) of the beginning backplane segment **240**.

In this embodiment, the structure and functions of all the portions are nearly identical to those of the previous one except for the configuration of the dedicated connectors **226**, **246** provided in the back sides **224**, **244** of the segments **220**, **240** and, as well, the structure of the connectors **266a**, **266b** provided in the bridge module **260**. As is intuitively understandable to those skilled in the art, the connectors of the 64-bit bridging are likely to requires more pin-outs, compared to the previous 32-bit bridging, which means that, in order to accommodate the number of pin-outs, the 64-bit bridge module **260** may be forced to be longer than the previous 32-bit one, as in this embodiment. The length **L** of the bridge module **260**, however, does not exceed 94 mm. This means that the bridge module **260**, when engaged with the backplane segments, does not extend beyond the connector J3 of the back side slots as is shown in FIG. **6**, thereby not interfering with the insertion of add-in cards, such as a transition module, into the slots in the back side of the modular backplane **200**.

Note that the present invention is also applicable not only to modular backplanes but also to monolithic backplanes having two buses. In other words, it is not necessary that the two backplane segments be physically separate from one another, as is illustrated in FIG. **9**.

While the present invention has been described with reference to a few specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.